Towards an Evaluation Framework for Business Process Integration and Management

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Abstract

Process-awareness in enterprise computing is a must in order to adequately support business processes. Particularly the interoperability of the (process-oriented) business information systems and the management of a company's process map are difficult to handle. Process-oriented approaches (like workflow systems and enterprise application integration tools) offer promising perspectives in this respect. However, a major problem for project managers is the accomplishment of economic-oriented assessments of such approaches. Currently, there exists no suitable evaluation framework. This position paper discusses important issues related to the introduction of such a framework. Doing so, we distinguish two evaluation areas: Business Process Integration and Business Process Management. While the former operates at the technical level of process and application integration, the latter addresses organizational process topics. Starting from those two perspectives we describe benefits, evaluation criteria and metrics that are relevant to set up an evaluation framework.

1. Introduction

Today, enterprises are continuously undergoing changes which are driven by various internal and external events [9]. Thereby, the alignment of information systems to business processes is crucial [8]. In the automotive industry, for example, a broad spectrum of enterprise information systems (e.g., supplier chain management systems, product data management systems) have to be aligned to various processes ranging from administrative financial services to knowledge-intensive engineering processes. Only the tight interweavement of both processes and IT systems assures an effective interoperability.

Without explicit knowledge about business processes information systems can only provide little support. Regarding the interoperability of enterprise information systems, process-oriented software technologies, like workflow management systems, application integration suites, or process portals offer promising perspectives. However, the introduction of such technologies, first of all, causes high costs: business processes have to be redesigned and existing information systems have to be aligned according to the optimized processes. Due to the occurrence of these additional costs, project managers must be able to assess the benefits as well as the cost-effectiveness of respective concepts.

Empirical studies conducted by Kleiner [7], for example, have shown that the effort to implement process-oriented applications can be significantly reduced when using commercial workflow management components. At least this indicates that processes can be implemented more quickly with process-oriented software technology when compared to classical programming. However, a major obstacle in this context is the unavailability of an evaluation framework which provides methods for the economic-oriented assessment of process-oriented software technologies. Indeed, cost benefit evaluation approaches (e.g., the *time savings times salary* approach or the *hedonic wage model*) exist [11], but none of them represents an evaluation approach that matches for process-oriented software technologies.

Costs are emphasized, but benefits are neglected and risks are ignored. Evaluation criteria for "process-orientation" in enterprise computing are not included at all. Nevertheless, criteria and methods for economic-oriented justifications are highly needed in practice. In fact, any manager who must decide whether to use innovative software technologies or not will demand a business case summarizing an investments' costs, benefits and risks.

The construction of an evaluation framework for process-oriented software technologies has to be based on well-defined evaluation criteria describing costs and benefits, metrics to quantify these criteria, and formal evaluation methods. This position paper describes our activities towards the development of an evaluation framework to assess costs and benefits of process-oriented software technologies. Doing so, we distinguish two evaluation perspectives: *Business Process Integration* and *Business Process Management* with the former as the technical enabler of the latter. Business process integration focuses on the technical integration and interoperability of processes and application systems (e.g., by providing middleware connectors and message brokers) to enable seamless business process execution. Internal integration includes all integration aspects within one enterprise. In contrast, external integration focuses on cross-organizational integration patterns. Business process management refers to the alignment of business processes with an organization's strategic goals. Aspects included are the design, implementation and management of process-oriented architectures, and the establishment of process performance measurement systems, and the utilization of process engines to control the flowlogic, to automatically analyse process runtime data, and to support business process changes.

Our work is part of the $\text{PAIS}_{\text{CoBe}}$ project conducted at DaimlerChrysler. The overall objective is to systematically identify and estimate the factors that influence the costs (*Co*) and benefits (*Be*) of *Process-aware Information Systems* (PAIS). PAIS cope with both business process integration and business process management issues. In this project case studies, surveys, experiments and tool comparisons are accomplished to analyse relevant factors and their impact on costs and benefits.

Sections 2 and 3 present important benefits, evaluation criteria and metrics regarding the quantification of business process integration and management. Section 4 discusses related work. The paper concludes with a summary and an outlook.

2. Business Process Integration

One of the reasons enterprises are facing the challenges of integration is the way they were organized in the past. Applications were implemented in a function-oriented way either without any process support or with the logic of process fragments being hard-wired in the application code. Each business function had defined its own business entities (e.g., data structures) without considering how other information systems had represented the same entities. Altogether, enterprise information systems were neither designed to interact with each other nor with the information systems of other enterprises (e.g., suppliers).

2.1. Background Information

Today, business operations are provided by a multitude of enterprise-wide application systems (cf. Fig. 1). Some of these applications include extensions to integrate business partners in order to realize the *extended enterprise*. These application systems have to be tightly integrated to provide business process support. Another motivation for business process integration has aroused from the need to systematically connect legacy applications with newly developed or bought-off-the-shelf software components.

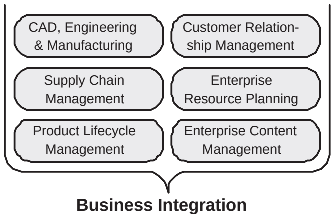

Figure 1. Integrating enterprise-wide information systems.

Business process integration allows the sharing of data information and business processes among connected applications and data sources. It is typically implemented through the use of application-to-application modules (integration connectors), object-oriented middleware or message brokers, and multi-tier application server platforms. Commercial integration suites combine these tools and concepts, and they provide a scalable and open platform for developing integrated end-to-end business processes. Regarding enterprise integration two major approaches can be distinguished:

- *Application-to-Application Integration* (A2Ai). A2Ai (or *internal integration*) focuses on the alignment of business processes and applications within one enterprise and therefore addresses both business and technical issues. A2Ai is also known as *Enterprise Application Integration* (cf. Fig. 2).

- *Business-to-Business Integration* (B2Bi). B2Bi (or *external integration*) focuses on the alignment of business processes and supporting software systems that typically span across several enterprises or business units. Thereby, B2Bi does not only requires the exchange of business events between distributed trading partners, but also demands the integration of business processes with back-end applications.

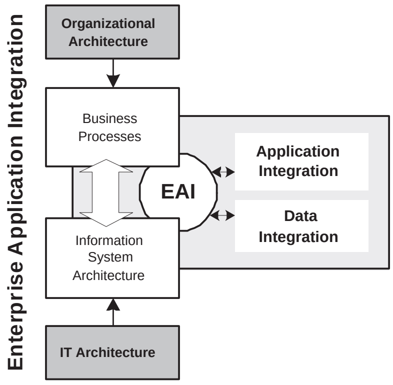

Figure 2. Enterprise Application Integration covering applications and data structures.

Altogether, business process intelligence provides an approach for technically connecting enterprise information systems in order to enable business process automation. The inclusion of external trading partners and their processes becomes possible as well, but constitutes a more advanced scenario which is outside the scope of this paper.

2.2. Evaluating Business Process Integration

In the following, we describe evaluation criteria and suitable metrics that help to set up an evaluation framework:

- *Legacy Integration*. Legacy systems are not defined by age, language, platform, or data structure. Following [13] an application system can be considered as a legacy system if it is functioning in a production environment. Legacy integration focuses on the integration of enterprise information systems, i.e., on the integration on the application level and not on the process level. Issues determining the characteristics and complexity of legacy integration are related to business relationships (e.g. the number of interfaces), business interactions (e.g., the frequency of interacting with another system), and transaction duration (e.g., the time to provide a function result). Logical data definitions, physical data formats, and aspects regarding semantical data integrity can be subject to evaluation as well.

  Metrics to evaluate legacy integration include the *time to implement a system connector*, the *time to adapt a system connector* if the underlying information systems change, or the *time to connect a legacy system*.

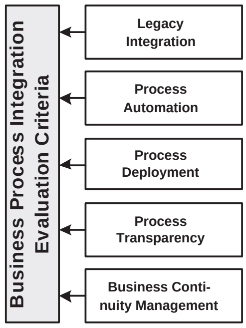

Figure 3. BPI evaluation criteria.

- *Process Automation*. Process automation refers to the use of information systems to automate business processes. Motivations for process automation are to automate the flow of activities, to coordinate the assignment and distribution of work among individuals, and to manage the completion of activities. The benefits of process automation could be a significant reduction of process cycle times, a shorter time-to-market, and fewer unexpected process delays. Two types of automation can be distinguished: *fully automated* processes (with no human intervention required), and *semi-automated* processes (with some human intervention required).

  Some metrics can be used to evaluate process automation. Examples are the *total number of business processes fully automated*, the *time to set up a fully automated business process*, the *amount of resources to set up a fully automated business process* or the *number of processes that can be upgraded to fully automatic execution using a process-oriented software technology*.

- *Process Deployment*. Enterprises cannot afford to slowly replace or deploy business processes. Instead, enterprises request for business agility and real-time connectivity between people, systems, and business entities. Facing these challenges, business process integration can be useful, as it supports the rapid deployment of business processes while leveraging the existing IT infrastructure.

  Metrics that can be used to measure process deployment efficiency are the time needed to implement a new business process (*time to implement a business process*) or the time needed to adapt an already existing business process to changed requirements (*time to change a business process*). Another evaluation criterion concerns error costs as integration promises to reduce errors made during process deployment (though not yet empirically proved). To quantify occurring errors, various error metrics like *defect density* (DD) or *mean time to failure* (MTTF) can be used. MTTF measures the time between failures and DD measures defects relative to the software size (e.g., measured in lines of code or function points). Metrics that can be used in this context are the *number of defects made during business process deployment*, the *number of defects occurring after business process deployment*, or the *time till failure after business process deployment*. By assigning error data to financial indicators (e.g., the costs to remove a defect) the impact of business process integration regarding process deployment can be quantified as a cost factor.

- *Process Transparency*. In an integrated IT infrastructure applications can be provided with knowledge about the entire business process background (e.g., knowledge about network technologies, application interfaces, or process participants). Such knowledge can be used to identify (and finally optimize) cost-intensive process activities (e.g., the unnecessary allocation of valuable resources).

  Metrics to quantify process transparency can be the *Number of Fully Traceable Business Processes* or the *degree of traceable activities of a business process*. To assign process activities with costs, *Activity-Based Costing* (ABC) can be used. ABC is a method for allocating costs to products and services, and constitutes therefore a means for planning and control. It can help enterprises to gain better insights into activities and business processes by formalizing their costs. Altogether, ABC allows attributing costs to activities and products more accurately than traditional cost accounting methods.

- *Business Continuity Management (BCM)*. Evaluating a process-oriented software technology Business Continuity Management (BCM) can be relevant, too. As BCM assures the technical continuity of business processes in the event of a disruption (e.g., the breakdown of a supporting information system) it has to be analysed in the context of business process integration. Generally, an incident is any event that seriously impairs, interrupts or halts essential business processes at one or more locations. An effective *Business Continuity Plan* can be helpful to handle the disruption of business processes. Such a plan must address basic process assets, i.e., process activities, process participants and owners as well as supporting information systems.

  Metrics to evaluate a technology's impact on business continuity can be the *number of process suspensions in a given period of time*, the *time to restart a business process after interruption*, or the *time without a business process suspension*.

Following these criteria, the impacts of a process-oriented software technology can be assessed on a technical level. Besides, a second evaluation area can be business process management, which particularly addresses organizational aspects.

Legacy Integration	**M01**	*time to implement a system connector*
	M02	*time to adapt a system connector*
	M03	*time to connect a legacy system*
Process Automation	**M04**	*total number of business processes fully automated*
	M05	*time to set up a fully automated business process*
	M06	*amount of resources to set up a fully automated business process*
	M07	*number of processes that can be upgraded to fully automatic execution using process-oriented sw technology*
Process Deployment	**M08**	*time to implement a business process*
	M09	*time to change a business process*
	M10	*number of defects made during business process deployment*
	M11	*number of defects occurring after business process deployment*
	M12	*time till failure after business process deployment*
Process Transparency	**M13**	*number of errors occurring after business process deployment*
	M14	*number of fully traceable business processes*
	M15	*degree of traceable activities of a business process*
Business Continuity Management	**M16**	*number of process suspensions in a given period of time*
	M17	*time to restart a business process after interruption*
	M18	*time without a business process suspension*

Figure 4. BPI evaluation criteria and metrics.

3. Business Process Management

Business process management (BPM) aims at the support of business processes using process-oriented techniques and software to design, enact, control, and analyse business processes [14]. Process modeling and analysis issues as well as the system-supported control and monitoring of processes are addressed. Its basic goal is to adequately handle an enterprise's process map and its evolution.

3.1. Background Information

BPM enables a new type of software architecture, not only based on business objects, but on business processes as well. For this purpose, BPM delivers a set of process management technologies that enable the automated orchestration of business processes and the management of related information. BPM tools, for example, typically provide a build time component for graphically modeling business processes in the ”as is” and ”to be” states. Furthermore, BPM is usually supplemented by *Business Process Modeling and Analysis* components to support a-priori process analyses as well as by features to support posterior process analyses based on real process data.

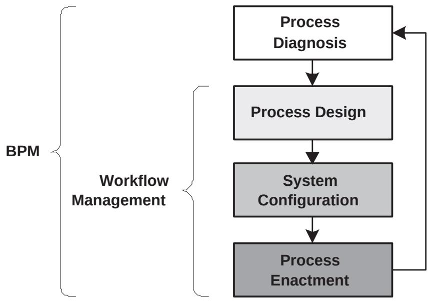

Figure 5. The BPM Lifecycle.

Van der Aalst [14] has introduced the BPM lifecycle (cf. Fig. 5) to illustrate all stages of a business process' lifecycle. Every business process has to be (re)designed in a first step by using business process modeling and analysis tools (*Design Phase*). After this, business processes are implemented in the *Configuration Phase* resulting in process-aware information systems (e.g., enterprise resource planning systems or product data management applications). Instances of the implemented business processes are executed in the *Enactment Phase*. Finally, processes are analysed in the *Diagnosis Phase* to identify potentials for process improvement (e.g., resource allocation bottlenecks). It is the availability of specific process intelligence concepts (e.g., process mining) that enhances traditional workflow management approaches to BPM (cf. Fig. 5).

Besides BPM, there are many other concepts, methods and tools that focus on the management of business processes in enterprises. Examples include Total Quality Management, Simultaneous Engineering, Balanced Scorecards, Six Sigma, and Business Process Reengineering. Figure 6 puts BPM in correlation to other management approaches.

Many organizations expect benefits from investments in BPM technologies. Nevertheless, there is often only little or no direct link between what organizations do to gain process improvements and how successful respective actions are. To establish such a link, evaluation criteria and metrics to quantify assumed benefits are needed.

Management Approach	BPM Borderline
Strategic Management	Pre-Condition for BPM
Value-oriented Management	Compatible with BPM
Refactoring	Compatible with BPM
Total Quality Management	Supported from BPM
Customer Relationship Management	Supported from BPM
Knowledge Management	Supported from BPM
Asset Management	Supported from BPM
Lean Management	Supported from BPM
Simultaneous Engineering	Supported from BPM
Change Management	Important appendix of BPM
Benchmarking	Important appendix of BPM
Balanced Scorecard	Important appendix of BPM
Six Sigma	Important appendix of BPM
Business Process Re-Engineering	Part of BPM
KAIZEN	Part of BPM
Activity-Based Costing	Part of BPM

Figure 6. BPM and other approaches [12].

3.2. Evaluating BPM

In the following, we describe evaluation criteria and suitable metrics that help to set up a BPM evaluation framework:

- *Process Alignment*. The process-oriented alignment of information systems must quickly adaptable to changes. When business processes are spread across multiple applications, this alignment can be difficult to sustain. To enhance process alignment, it is important to detect discrepancies between the modeled and the observed execution behaviour of processes, and to continuously adapt the process models. *Process Mining* and *Delta Analyses* [15] can help to detect such discrepancies between modeled and observed behaviour.

  Process-oriented information systems are based on explicit process models. Creating such process models is a complex, time-consuming task. Process Mining can help to reduce the effort for designing new or changing existing process models. Starting from logged runtime data (*Audit Trails*) the focus is set on the derivation of a more optimal process model. Process mining is not restricted to performance data, but can also extract causal relations between process activities.

  Metrics to quantify process alignment based on Process Mining activities can be the *time to derive a new process model*, *time to implement a process model*, or the *time to redesign a business process*.

- *Process Implementation*. Today, business processes are usually implemented with IT support (e.g., work-

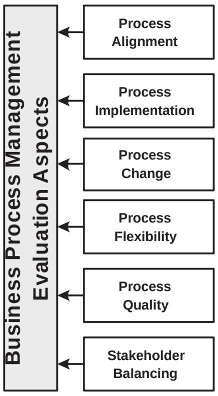

Figure 7. BPM Evaluation Criteria.

flow management systems). BPM promises to realize a faster implementation of business processes as the implemented information systems can be aligned in a process-oriented way.

Metrics to quantify BPM impacts regarding process implementation this can be the *time to implement a business process* or the *resources needed to implement a business process*, e.g., the number of person months.

- *Process Change*. Evolving enterprise environments frequently require process adaptations very often. BPM promises to support evolving business processes.

  Metrics to quantify a technology's process change capabilities can be the *time to change a business process*, or the *resources needed to change a business process*.

- *Process Flexibility*. To derive process flexibility evaluation criteria, it is useful to introduce different flexibility levels. These levels can then be analysed separately. In this context, the *Goal Question Metric* approach can be used to assess stakeholder success models and to further derive useful metrics [5]. GQM is a method for the systematic definition, establishment, and exploitation of measurement programs supporting the quantitative evaluation of software processes and products [10].

  Metrics to estimate process flexibility can be the *time a business process is running without external intervention* or the *degree of on-demand resource allocation of a business process*.

- *Process Quality*. Process quality is a key element to achieve high product quality. It can be only improved, if the respective processes are well controlled (coordinated). This is the case, if process errors can be excluded from the very beginning.

  Process quality can be quantified based on errors [12]. Metrics to measure process quality can be *first pass yield* (FPY) or *six sigma*. FPY is the percentage of a process' output objects that are free of errors and that do not require reoperation. The goal of six sigma is to reduce process output variation so that on a long term basis this will result in no more than a given number of defect (e.g., *defects per million opportunities*).

- *Stakeholder Balancing*. BPM enables an easier balancing of the competing requirements of users, acquirers, developers, and maintainers of a process. This is important as non-balanced stakeholder interests can lead to business process delays. One approach is the *Model Clash Spiderweb* [3].

  Metrics to quantify the effects of BPM regarding stakeholder balancing can be the *total number of conflicts between all stakeholders*, the *time to resolve a model clash* or the *complexity of a model clash spiderweb*.

Process Alignment	**M01**	time to derive a new process model
	M02	time to implement a process model
	M03	time to redesign a business process
Process Imple-mentation	**M04**	time to implement a business process
	M05	resources needed to implement a business process
Process Change	**M06**	time to change a business process
	M07	resources needed to change a business process
Process Flexibility	**M08**	the time a business process is running without external intervention
	M09	degree of on-demand resource allocation of a business process
Process Quality	**M11**	first pass yield (FPY)
	M12	defects per million opportunities (DPMO)
Stakeholder Balancing	**M13**	total number of conflicts between all stakeholders
	M14	time to resolve a model clash
	M15	complexity of a model clash spiderweb

Figure 8. BPM evaluation criteria and metrics.

Following these evaluation aspects, the impacts of a process-oriented software technology are addressed on the level of business processes.

4. Related Work

There are other approaches in enterprise computing that focus on IT evaluations and economic-driven software engineering research. The overall goal of these approaches is to develop fundamental knowledge and practical techniques to increase the value created over time by software and IT projects, products, and portfolios [2] or to identify process improvement potentials by analysing (real-time) process execution data. In the following, some approaches are sketched and discussed in the context of this paper.

4.1 The GRAAL Framework

The *GRAAL Framework* [16] investigates the alignment of an enterprise's *Information and Communication Technologies* (ICT) to its business processes and services. Descriptive goals are to acquire knowledge about how the mentioned alignment can be generally maintained. Prescriptive goals are to develop new techniques (e.g., agile development methods) that help to maintain the alignment. To achieve these goals it is necessary to identify and evaluate suitable techniques. Therefore, this framework defines different enterprise layers (cf. Fig. 9), each of them representing a separate evaluation baseline. In our opinion, the GRAAL framework provides a broad enterprise computing evaluation approach. However, process-oriented evaluation criteria are not included. The GRAAL framework rather provides a static perspective. To assess process-oriented software technology, however, a more focussed approach is needed including specialized evaluation criteria, i.e., to describe a technology's ability to enhance business process and information system evolution.

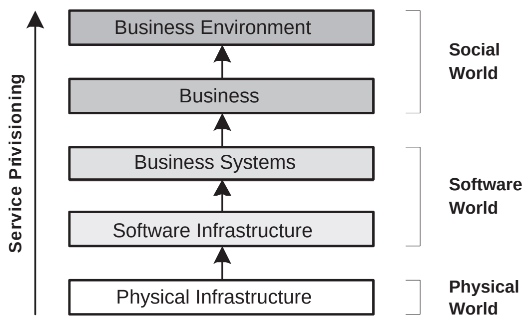

Figure 9. GRAAL Evaluation Baselines.

4.2 The e3 Value Framework

The *e3 Value Framework* is a multi-viewpoint requirements engineering method that is based on analysing e-commerce initiatives through stakeholder-based viewpoints [1]. Its overall goal is to define, derive and analyse multi--enterprise relationships, business cases and requirements. The framework defines three evaluation perspectives each of them representing an evaluation baseline to evaluate stakeholder interests and derive suitable requirements. The *business value viewpoint* focuses on the way of economic value creation, distribution and consumption in multi-actor networks. It enables setting up a prediction of revenues and expenses, based on exchanges of valuable goods and services between multiple actors. The *business process viewpoint* focuses on a way to put the value viewpoint into operation in terms of business processes. It examines operational fulfilment of business processes. The *information system viewpoint* focuses on the information systems that enable and support processes. Regarding the evaluation of process-oriented software technologies, the e3 value framework is helpful, but not sufficient. In fact, a more holistic approach is needed (e.g., including evaluation criteria to evaluate not only stakeholder success models and requirements, but process-oriented aspects). Nevertheless, this approach introduces important issues concerning the derivation of requirements.

4.3 Value-based Software Engineering

Value-Based Software Engineering (VBSE) [2] integrates value considerations into software engineering principles and practices. Seven key elements (benefits realization analysis, stakeholder value proposition elicitation and reconciliation, business case analysis, continuous risk and opportunity management, concurrent system and software engineering, value-based monitoring and control, and change as opportunity) are defined that represent the foundations for VBSE. As can be seen, the analyses of costs, benefits, risks, and stakeholder interests plays a significant role. Altogether, VBSE is an approach that combines existing techniques and management approaches with a new value-oriented focus. Due to the enormous number of integrated concepts VBSE is still in a conceptual stage. Therefore, as there exists no VBSE best practice, it is hardly possible to transform VBSE into praxis. As VBSE focuses on software development in general, it lacks to adequately support the evaluation of process-oriented software technology, though interesting evaluation concepts are included.

4.4 Business Process Intelligence (BPI)

Organizations more and more realize that gaining knowledge about their processes may imply many benefits that can justify the costs of respective solutions. Business process intelligence (BPI) applies business intelligence concepts (e.g., analytical applications) to business processes [4]. It is implemented as a set of integrated tools providing features for the analysis, mining, prediction, control, and optimization of processes. In particular, it provides valuable information (e.g., about the adequacy of provided business functions [6]) for the alignment of information systems to business processes. It can also be used to identify critical scenarios that may occur during the execution of a business process (e.g., resource over-allocations or bottlenecks, unnecessary waiting and idle times). Process mining (as an important feature of business process intelligence) allows for the derivation of optimized process models. This, in turn, reduces effort-intense manual process analyses. Particularly the increasing use of process-oriented information systems (e.g., enterprise resource planinng systems or supplier chain management systems) in enterprises has been an enabling success factor in this respect (as more and more data can be collected real-time from process-supporting information systems). BPI can be applied using contemporary BPI tools. Examples include *Websphere Business Integration Monitor*, *ARIS Process Performance Manager* and *BizTalk Server Business Activity Monitoring Framework*.

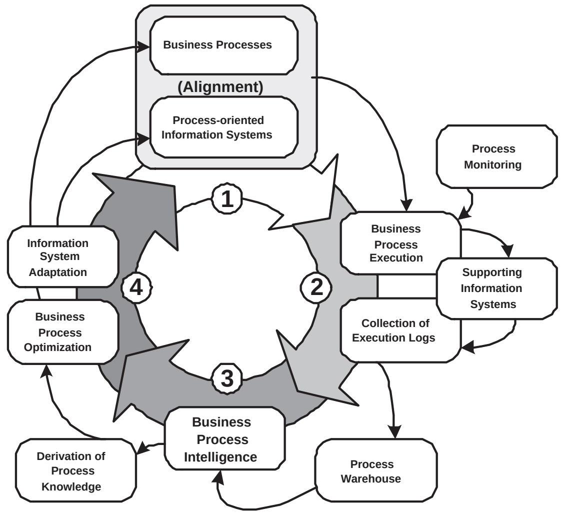

Figure 10. The BPI Lifecycle.

5. Summary and Future Work

Executives that have to decide whether to use process-oriented software technologies or not typically demand for a business case outlining an investment's costs and benefits. However, currently there exists no evaluation framework to support investment decisions regarding process-oriented software technologies. This paper has discussed relevant issues for the development of an evaluation framework to assess costs and benefits of process-oriented software technologies. Therefore, we distinguished between the two evaluation perspectives *Business Process Integration* and *Business Process Management* with the former as the technical enabler of the latter. Following this distinction we identified success-critical evaluation criteria. To quantify the impacts of process-oriented software technologies we have additionally assigned first metrics to the described evaluation criteria.

We are aware of the problem that to set up a detailed evaluation framework, both the evaluation criteria and the metrics have to be described more precisely. It is our goal not only to develop a framework which can be used to describe and evaluate process-oriented software technologies, but process-oriented information systems as well. Therefore, we plan to accomplish case studies, surveys, experiments and tool comparisons to analyse relevant approaches towards their economic impacts, costs and benefits. The development of suitable cost models to quantify economic impacts of respective investments and the transfer of the framework into the practice are major requirements.

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